Water-Rock Interaction on the Hadean Earth: A Modeling Study

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Research in our group focuses on the role minerals may have played in prebiotic synthesis processes. What type of minerals would have been common on the Hadean Earth and which of these minerals would have been suitable catalysts is an important question. Constraining the mineralogical composition of early Earth is a daunting problem because there are no rock older than about 3.96 byr old. Most scientists think that life originated before that time. After the last impact-induced global melting event, Earth began an episode of fractionation that led to a bimodal rock composition. The prevailing notion has been that the early crust would have formed from high MgO, or komatiitic magmas. Remelting, or multiple-stage melting, of this crust would have produced sodium-rich granites (tonalities). The tonalities would have been the first vestiges of continental crust on Earth. In the context of mineral-based catalysis, we are interested in the formation of secondary minerals, such as zeolites and clays.

To explore the type of alteration products that could have formed via water-rock interaction, we modeled a number of scenarios to represent some possible endmember conditions. The models are very simple, i.e. react komatiite or tonalite with pure water. We conducted two sets of calculations, one set in which we maintained the mineral assemblage in equilibrium with CO_2 at a partial pressure of either 1 or 5 atm. The most important outcome is that the assemblage of secondary minerals is strongly dependent on the constraints placed on P_{CO2} (i.e, constant or variable).